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DEVELOPMENT OF A CONTAINER FOR HANDLING, TESTING, AND STORING DISCRETE MICROELECTRONIC COMPONENTS

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16. ABSTRACT

A container has been developed for handling, testing, burning-in, and storing discrete microelectronic components without removal from the protective package. The package was designed to accommodate the Leadless Inverted Device (LID) and other carrier-mounted active devices and chip-type discrete resistors and capacitors. Before the indicated development, components were handled and tested in various ways, some of which resulted in damage or contamination. The basic design of the container utilizes precision-machined printed circuit boards and chemically milled (photoetched) contact springs. Included in this design for protection is an O-ring-sealed cover. Methods of fabrication and limitations of the current hardware are presented. Current applications of and possible extensions to the technology are discussed.

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DEVELOPMENT OF A CONTAINER FOR HANDLING, TESTING, AND STORING DISCRETE MICROELECTRONIC COMPONENTS

INTRODUCTION

Many useful discrete devices have become available in recent years for use in hybrid microelectronic circuits. Manufacturers have expended great efforts to produce practical carrier-mounted active devices and chip passive devices, which are being used in large numbers. The area of concern is the packaging, handling, testing, and burning-in of the parts. This report presents a packaging concept that provides a means for overcoming the problem. The design requirements and development of hardware for this container will be discussed.

DISCRETE COMPONENT PROBLEM

Discrete microelectronic components are used in most hybrid integrated microcircuits. Such a microcircuit (Fig. 1) is defined as an integrated circuit fabricated on an insulating substrate and utilizing some combination of monolithic chip, thick- or thin-film elements, and discrete components. Discrete components are individual parts such as resistors, transistors, or chip capacitors, which can be individually transported, packaged, and measured. The container is designed to overcome the problems associated with holding, testing, and storing these discrete components.

Cetain features are common to most of the discrete components. Semiconductor chips are often mounted on small ceramic carriers for ease of handling and physical protection. The carriers, containing thick-film metallized areas, permit semiconductor manufacturers to make critical welds to the semiconductor chips at their plants. The two principal types are the Leadless Inverted Device[1] (LID), which has four or more posts topped with pads (Fig. 2), and the channel carrier, which has three areas that serve as

1. Use of trade names or names of manufacturers in this report does not constitute an official endorsement of such products or manufacturers, either expressed or implied, by the National Aeronautics and Space Administration or any other agency of the United States Government.

connection areas (Fig. 3). The LID, as indicated by its name, is designed to be mounted with its pads down. However, it can also be mounted with the pads up, as is the channel carrier. With the pads up, interconnections are made to both types by wire bonds. Passive devices are usually of a rectangular cross section with attachment pads on the ends or corners (Fig. 4).

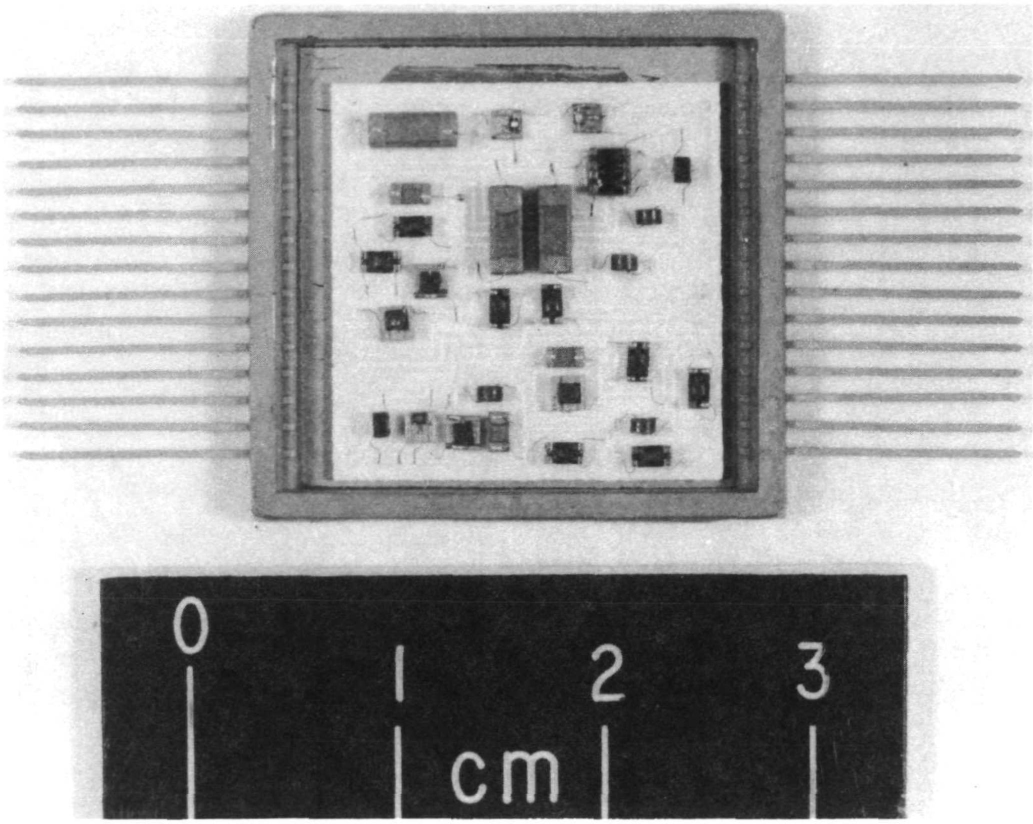

Figure 1. Hybrid microelectronic circuit.

At present most parts are shipped from the manufacturers in containers whose primary merit is economy. Some of the more objectionable methods of packaging and shipping are (1) sticking the parts to adhesive tape, (2) placing them in small pockets from which they can escape with ease when the box is opened, and (3) placing them in plastic bags which allow the parts to strike each other. However, there are some economical packages that hold the parts in soft channels and provide satisfactory handling. Even when this preferred type is used, however, the problems associated with testing, burning-in, and storing remain to be solved. In fact, the protected-storage problem starts when the discrete components leave the controlled environment of the manufacturer. The parts may be subjected to undesirable environmental and temperature changes during shipping.

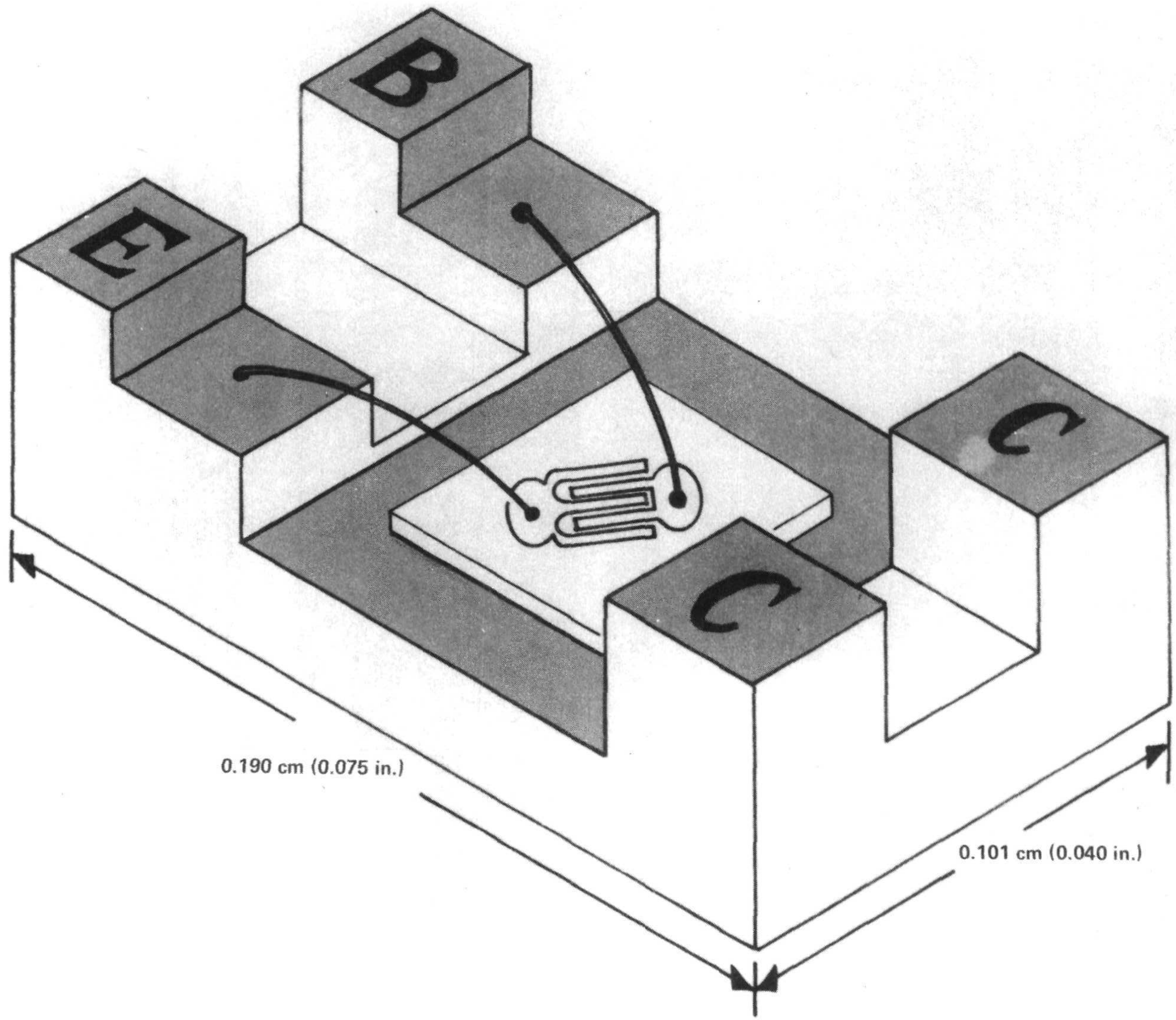

Figure 2. LID carrier.

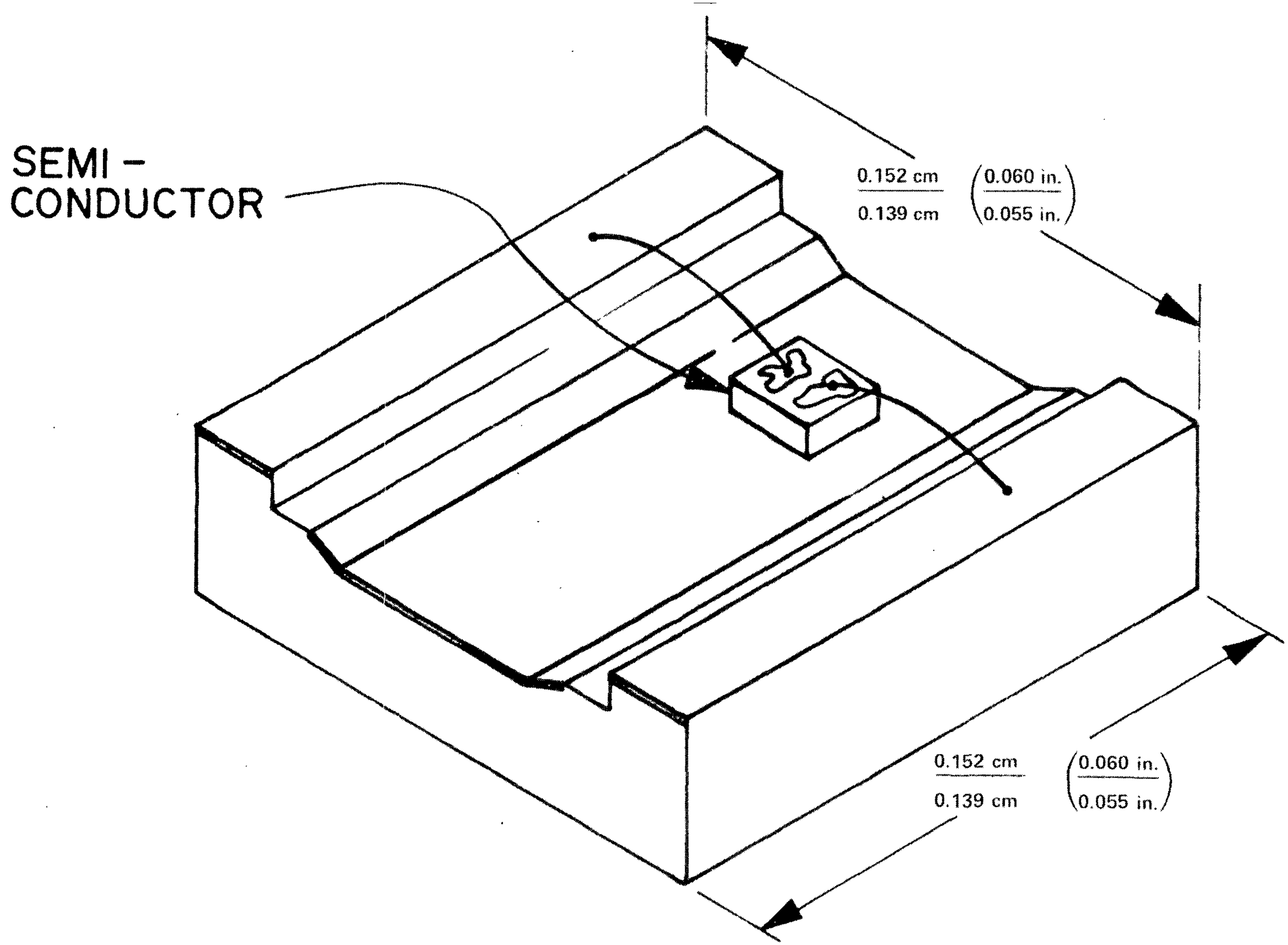

Figure 3. Channel carrier.

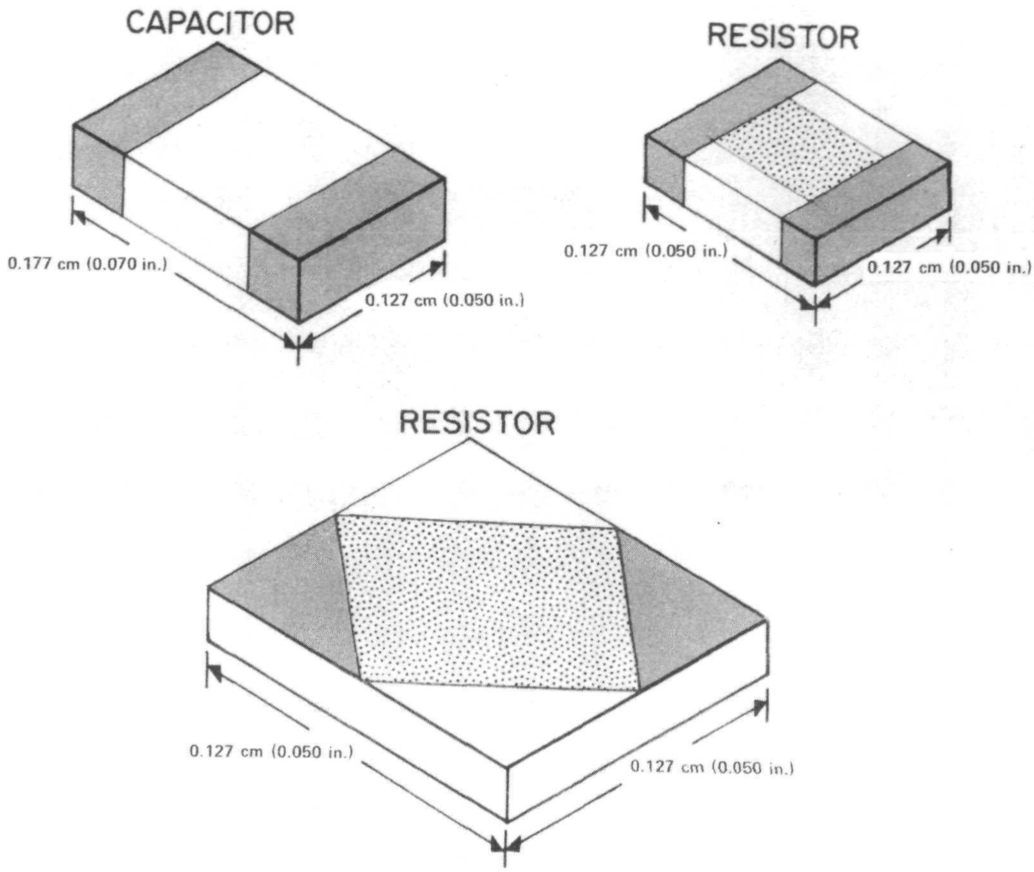

Figure 4. Typical passive chip components.

When the components are received by the purchasing activity, testing and burning-in must be accomplished. For testing, temporary probing may be done but often with some damage to the components. When more permanent connections are needed, the problem becomes more difficult. The methods of holding the discrete parts and the electrical connections often result in a permanent change or contamination of the parts. Even removal of the good parts from test boards can cause losses.

It is the policy of the Hybrid Microelectronics Research Section of the Astrionics Laboratory at the Marshall Space Flight Center to test all devices upon receipt and, if they are to be used in an integrated hybrid microcircuit, to give them a power burn-in. Before being assigned to a specific circuit, a component is given a final individual check. During testing, burning-in, and storage periods, physical and environmental protection are considered to be most important.

CONTAINER DEVELOPMENT

Basic Design

To overcome the problems encountered in handling and testing discrete microelectronic components, a special container (Fig. 5) was developed. The container consists of four different parts and serves as a package and a test fixture. One part is a printed circuit board, which has precision slots machined on one side and a conductor pattern etched on the other. The slots contain chemically milled springs that perform several functions. (These will be discussed in more detail later.) The area around the springs has a grooved cover of the same material as the printed circuit board. An O-ring in the groove forms a protective seal when the cover is secured to the board with screws.

The conductor pattern on the printed circuit board (Fig. 6) provides contacts into an edge connector and solder pads for connection to the contact springs. Holes are drilled in the centers of the etched pads to position the springs and provide electrical continuity through the board. On the reverse side of the board, guide pockets and slots (Fig. 7) provide precise locations for the contact springs and the discrete components that are to be loaded when the containers are put into use. A step is machined on the end of the board to allow insertion into the receptacle.

The springs that fit into the slots were designed to provide an electrical connection between the attachment pads of the discrete parts and the conductors of the etched circuit pattern. They also serve as guides and holders for the discrete parts.

The design of the covers was straightforward, each cover consisting of a recess, an O-ring groove, and four tapped holes. Although it was originally anticipated that a specially shaped O-ring would be required to fit the groove, it was found that a standard round configuration would work.

Generation of Artwork

The standard photoetch process is used for producing the conductor pattern on the printed circuit board. The artwork for the photographic

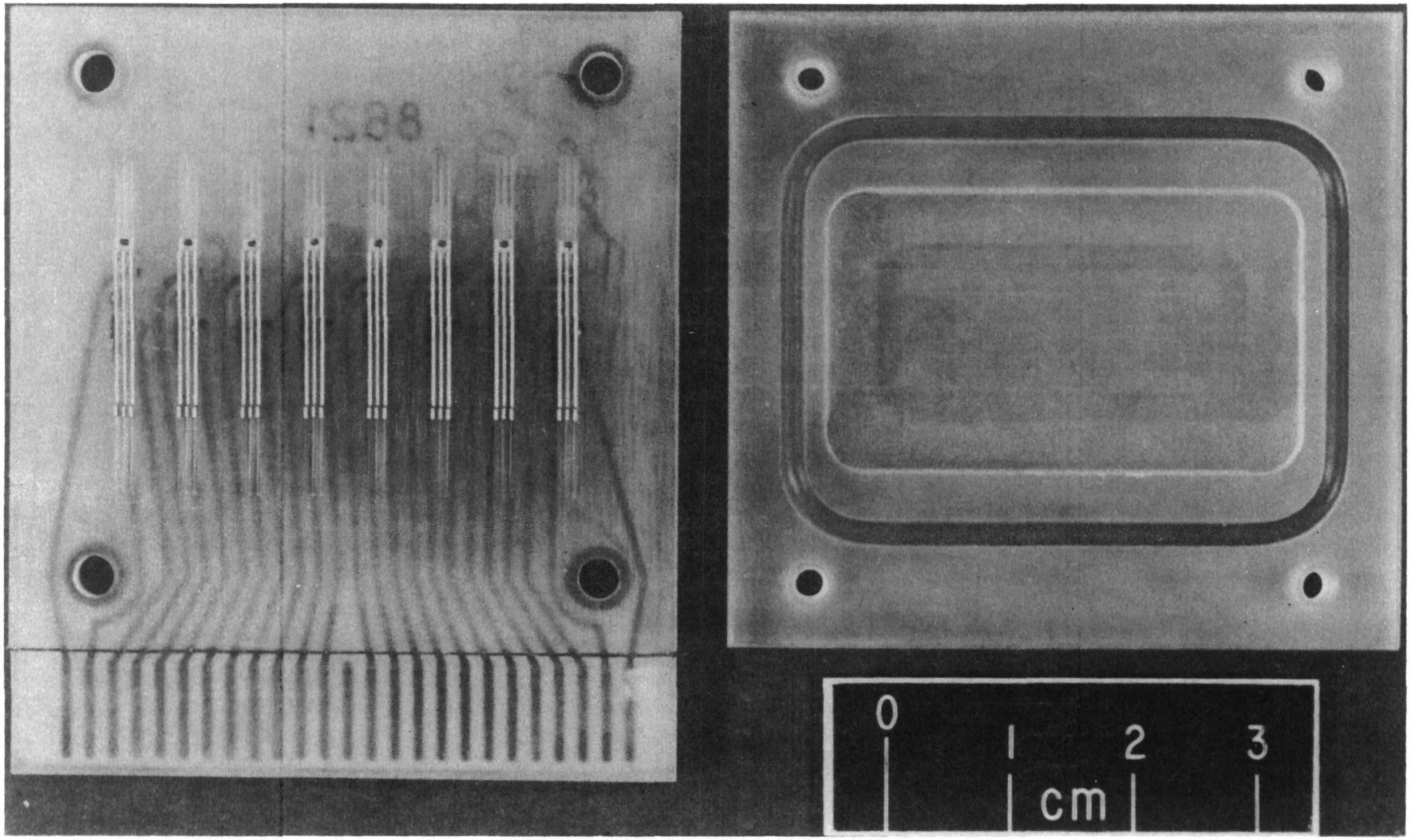

Figure 5. Channel holder assembly.

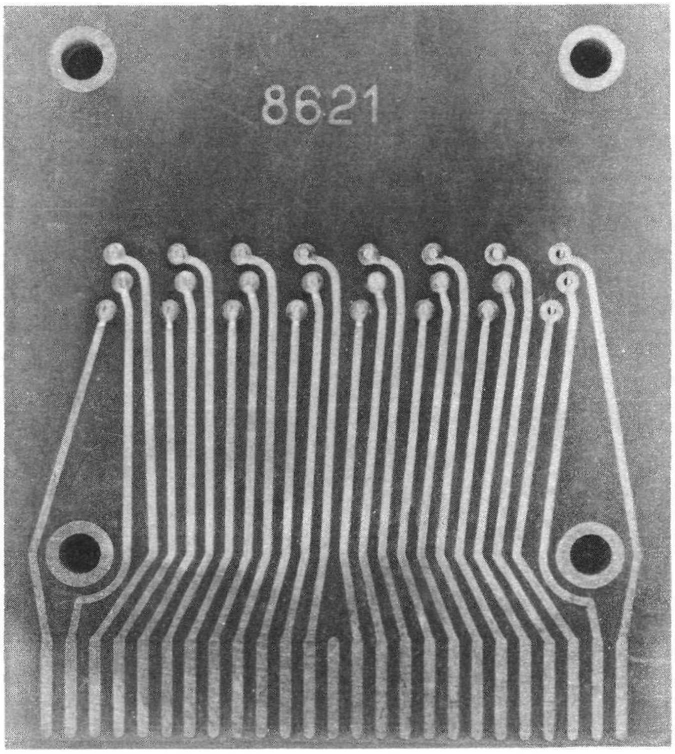

Figure 6. Printed-circuit interconnect side.

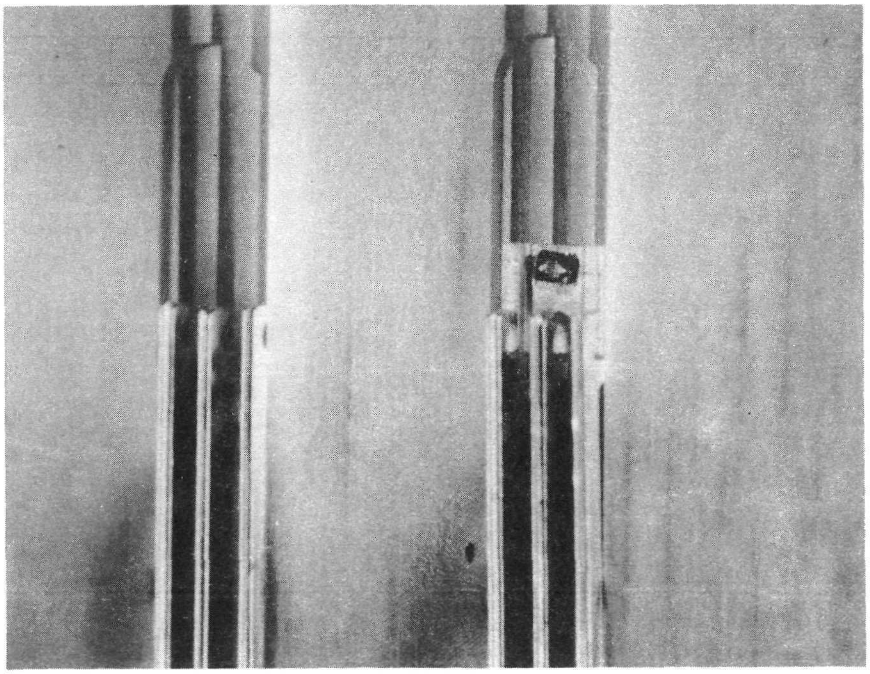

Figure 7. Guide pocket detail.

negative was generated at a one-to-one scale using a computer-controlled plotter at the Marshall Space Flight Center. The pattern was repeated by the computer six times, allowing six boards to be etched simultaneously. The artwork generator also was used for the photographic negative required for the contact springs (Fig. 8). Each spring outline was repeated 160 times to provide a sufficient yield from the chemical milling operation. The minor variations needed for the different springs were accomplished by the interchange of a few cards in the computer program. Even though liberal use was made of the computer-controlled plotter, all the work can be done by taping or cutting masters on a coordinatograph. These methods require more process steps because of reducing and repeating the patterns.

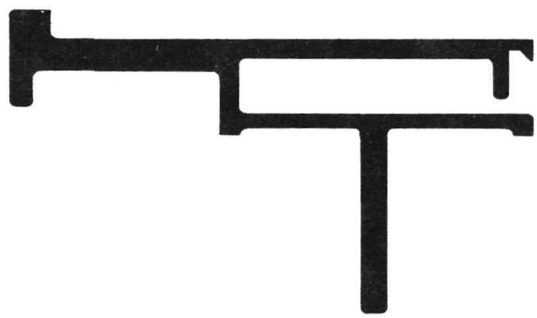

Figure 8. Contact spring.

Fabrication of Boards by Tape Control

Tape control was used for drilling and machining the printed circuit board, with the exception of sawing the spring slots. These were gang milled three at a time in a small, horizontal milling machine using standard slitting saws.

Etching of Springs

The contact springs are chemically milled 0.020-cm-(0.008 in.) thick beryllium-copper sheets. The etching was done in a spray etcher modified to provide planetary motion of the prepared sheet stock. The planetary motion was easily achieved by using an eccentric roller to drive the rotating stock holder. This produces a uniform etching across the 15.24-cm

(6-in.)-square sheet. The outline of each spring on the photographic negative was purposely made slightly undersized. When the proper overall dimensions were achieved in the etching, the edges around the springs had a slightly pointed cross section at the center. This resulted in a pointed contact tip and did not interfere with other functions of the spring. After etching, the springs were gold plated.

Materials Limitations

The material selection made for the containers involved some trade-offs. The slots on the precision-machined printed circuit board require a material that has reasonable machinability and good electrical qualities. The 0.056-kg (2-oz) copper-clad Rexolite 1422 material meets these requirements. The major drawback is that this material is pliable at 398.15°K (125°C) and therefore cannot be used for high-temperature tests. It is suitable, however, for room-temperature power burn-in and other tests required of discrete components. Suitable materials were chosen for the other parts of the container.

Design Variations

Active-Device Handling. When the design and hardware for the ceramic channel carrier were considered successful, design variations were initiated to accommodate other configurations. Modifications were made that permitted the mounting of LID devices. To accomplish this, the centerline of the guide pocket was rotated 23 degrees and the necessary changes in contact-spring length were made (Fig. 9). These changes were easily accomplished by changing cards in the computer programs.

Another extension of the channel carrier design was to make containers suitable for dual-channel carriers with six contact areas (Fig. 10). This arrangement allows eight dual carriers to be mounted in what is essentially a double-ended version of the original design. Either end of the board can be engaged in an edge connector for testing. If it is desired to make simultaneous connections to both ends of a container, a flat-conductor cable provides a properly oriented return to a second edge-connector receptacle.

Passive-Device Handling. In addition to the active devices already discussed, many two-terminal passive devices are used in hybrid integrated

circuits. To provide for these and to take advantage of the less critical alignment problems presented by two contacts versus three or more, several changes in design were considered. A consideration in the redesign was that the majority of passive devices are parallelepipedons with contact areas on opposite ends. This simple geometry permitted the development of a simple yet more versatile container.

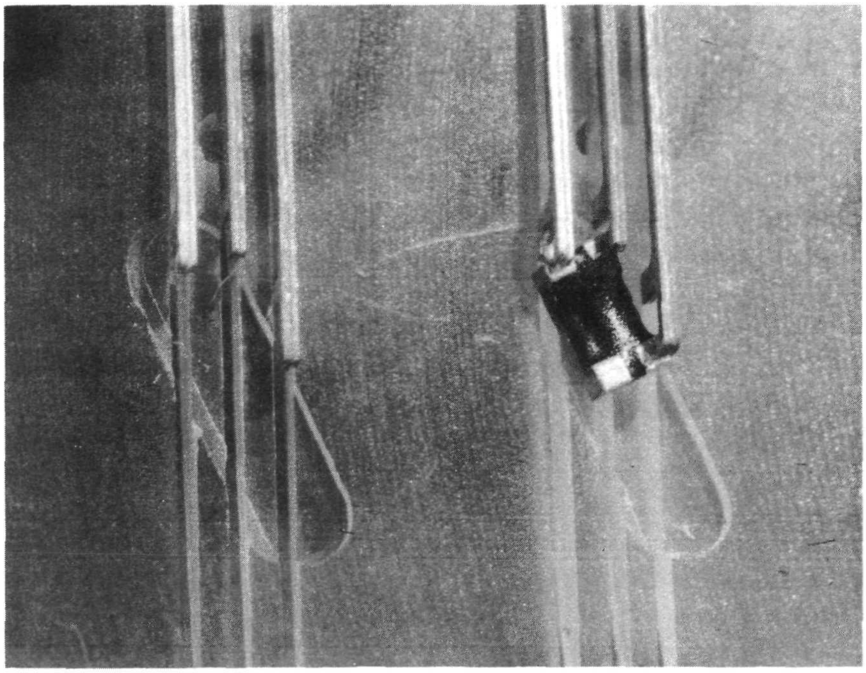

Figure 9. LID pocket detail.

The greatest saving of time and expense was on the printed circuit board. Alignment pockets and spring guide slots were eliminated, thereby requiring only hole drilling and outside trimming for the machining operations. New springs were designed with two legs to provide the needed spring guidance. Also added was a triple-contact point to provide enough range to handle the various thicknesses of components (Fig. 11). The range of body sizes that can be handled without modification of this container is from 0.050 to 0.177 cm (0.020 to 0.070 in.) in thickness, 0.127 to 1.016 cm (0.050 to 0.400 in.) in length, and virtually any width within practical limits. Up to 12 components of 0.190-cm (0.075-in.) maximum length can be accommodated by each carrier. A reduced number of longer components can be mounted by leaving some springs unused.

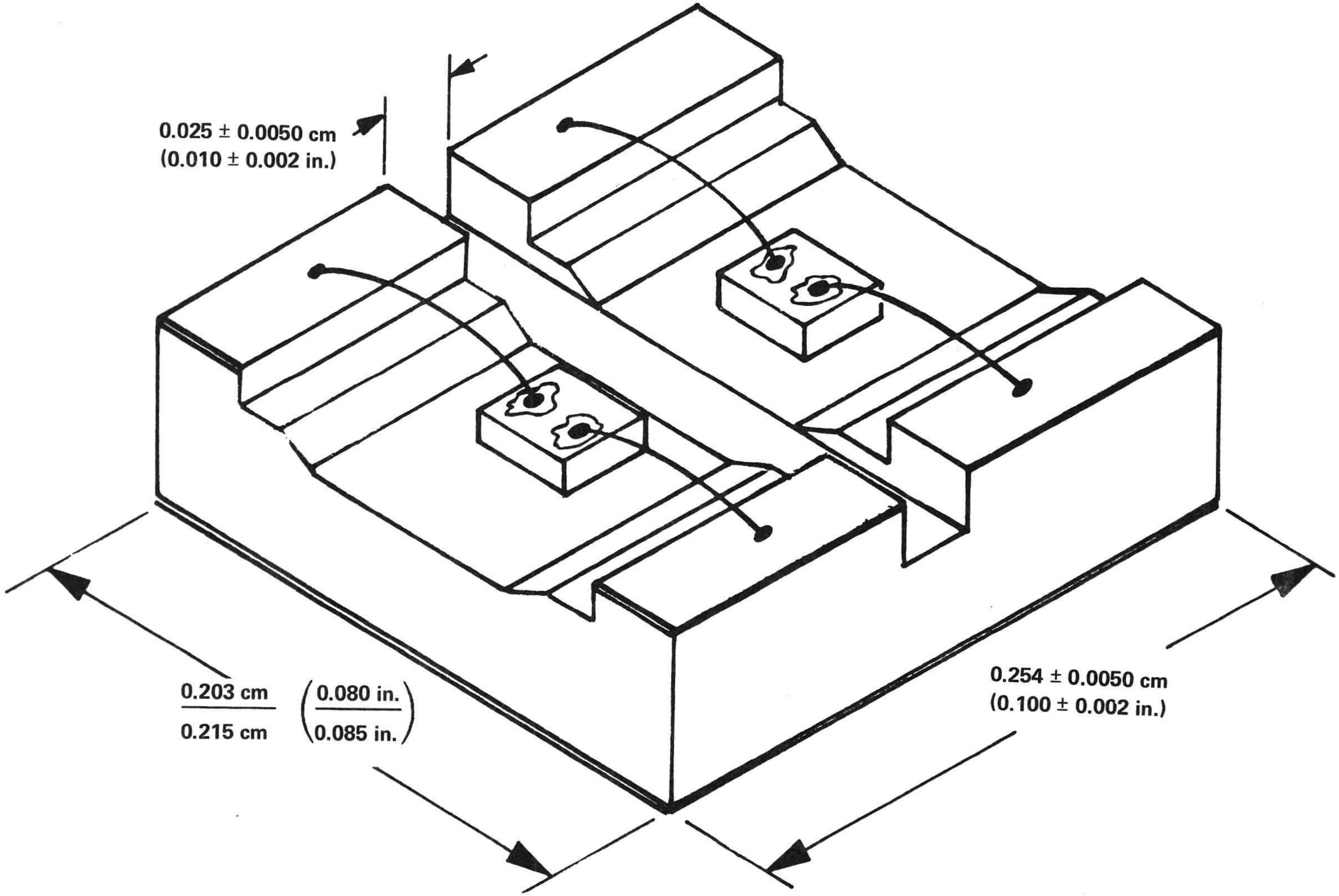

Figure 10. Dual-channel carriers.

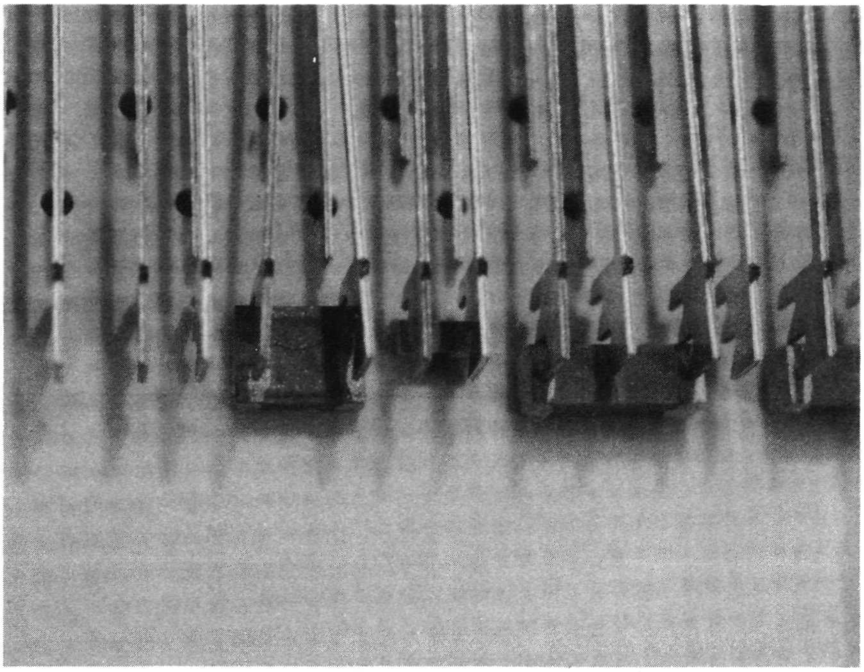

Figure 11. Passive-device holder.

The simple machining requirements of the passive component board increased the range of usable board materials. A glass-filled-epoxy printed circuit board material was used to enable operation to 398.15° K (125°C) for elevated-temperature tests.

APPLICATIONS

Loading Components

The most efficient use of these containers is to load them with the discrete microelectronic components at the manufacturing plant. This eliminates double handling of the sensitive semiconductor parts. In addition, the container can be filled with dry nitrogen and sealed in the controlled atmosphere of that installation. It would remain sealed until the components were ready to be put into use after shipping, testing, burn-in, and storage.

Regardless of where it is done, the technique for loading and unloading the containers is simple. A small screwdriver and a pair of tweezers are the

only tools required. To load, the components are first placed in the guide pockets. Then the springs are depressed at the rear tabs by fingernail or small screwdriver to raise the contact end. The component is then slipped under the contact points until the entering end encounters the stops, which are integral parts of the springs (Fig. 5). After the components are loaded, the cover is secured by four screws. Unloading requires the reverse procedure.

Electrical Tests and Burn-In

For required testing and burn-in, the sealed carrier is plugged directly into an edge connector. The only restriction on testing is imposed by the temperature limitation of the printed circuit board material. This restriction can be overcome by using a higher-temperature material. However, a different material may be more difficult to machine than the Rexolite.

Storage and Handling

Since the carrier contains an O-ring seal, long-term storage should be in some protected atmosphere such as a nitrogen-filled dry box. For periods less than one year, the package provides sufficient environmental and physical protection. Carriers loaded with active devices have been dropped to the floor and rapped on a table without dislodging the components from under the contact springs.

Cost and Reuse

The present raw material costs are between $2 and $3 per container and manufacturing and assembly time is 3 hours per unit for batch lots of several dozen. Some of these labor and dollar costs are offset each time the container is reused.

Future Applications

The concept presented is adaptable to almost any discrete component used in hybrid integrated microcircuits except semiconductor dies. If the use

of these containers becomes sufficiently widespread, production costs can be significantly reduced. Molded or stamped parts would be practical for large production runs and automatic assembly equipment can be used.

A material first incorporated in the active-device containers was not entirely satisfactory because it could not be used in high-temperature tests. Therefore, another material which can withstand high temperatures has been substituted and these new containers should be available soon.

CONCLUSIONS

It has become a standard procedure to pre-test and burn-in discrete devices for use in high-reliability electronic assemblies. Hybrid integrated microcircuits are unique assemblies and the discrete components used in such packages are normally uncased and leadless. Therefore, to produce long-life high-reliability hybrid packages, handling containers such as described in this report are required to achieve pre-assembly burn-in on components. The Hybrid Microelectronic Research Section has completed several years experience using this concept, with excellent results. That is, the failure rate of components has been negligible on hybrid assemblies with parts burned-in using these handling fixtures.

APPROVAL

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